SF2 SEMANTIC FOLDING SENSOR FUSION

SF2 Systems – Precision Maintenance in Cleanrooms Without Retrofit

Conveyor Track Intelligence –
Developed during Infineon & ZEISS Thin[gk]athon

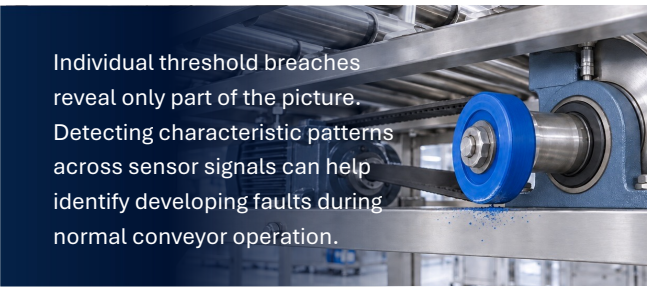
418.938
Sensor readings
processed

72
Condition features
per time step

15 m
Infineon test track

Defect Signatures
Reliably recognized
when passing faulty rollers

THE CHALLENGE – Detecting Wear Across Extensive Conveyor Networks



Individual threshold breaches reveal only part of the picture. Detecting characteristic patterns across sensor signals can help identify developing faults during normal conveyor operation.

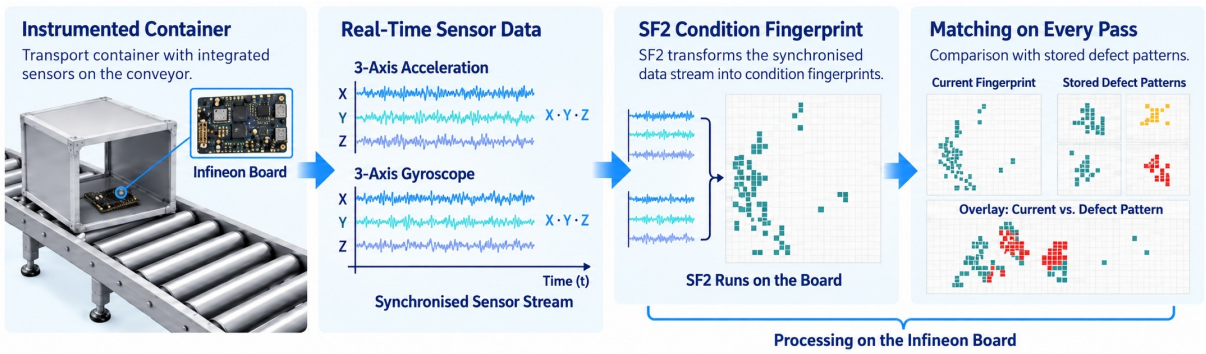
In semiconductor manufacturing, roller conveyors carry sensitive wafer containers over long distances through cleanrooms. Wear in rollers and drive components can compromise both product quality and equipment availability.

For maintenance teams, this presents several challenges:

- **Long transport routes** make faults difficult **to locate.**
- **Early signs of wear** can be difficult to identify in routine sensor data.
- **Infrequent defects** limit the availability of labelled training data.
- **Condition monitoring** needs to fit the existing conveyor infrastructure.

THE SF2 SOLUTION – Turning a Transport Container Into a Mobile Inspection Unit

During a Thin[gk]athon hosted by **Infineon Technologies** and **ZEISS Digital Innovation**, SF2 successfully recognised passages over known defective rollers in a supplied sensor dataset. SF2 then implemented its sensor fusion software on the **PSOC™ Edge E84 AI Kit**, creating an instrumented transport container that processes sensor signals in real time.



THE RESULT – Known Roller Defects Successfully Identified

Demonstrated at the Thin[gk]athon

- ✓ **Distinctive patterns visible** in the overlap trace
- ✓ **Monitoring through a mobile sensing container**
- ✓ **No additional sensors** installed along the conveyor
- ✓ **No custom data science** development required

SF2 recognises wear signatures via the instrumented mobile carrier, without additional sensors along the route.

HOW SF2 WORKS

1 Data Normalisation (Binning)

Raw sensor signals are assigned to standardised discrete categories, or bins, ready for semantic mapping.

2 Semantic Mapping (Semantic Dictionary)

Using only normal operating data, SF2 learns baseline behaviour & natural relationships between sensors, creating a model of healthy operation.

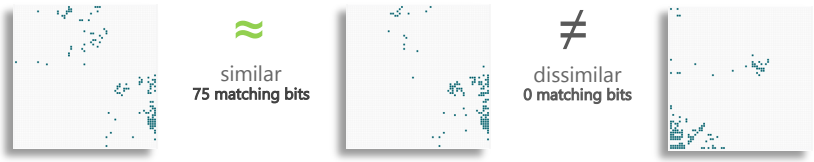
3 Fingerprint Aggregation (Stacking)

Individual process states are combined into stable fingerprints that capture the system's overall condition at a given moment.

4 Real-Time Interpretation (Comparison)

Current fingerprints are matched against stored defect patterns. Greater overlap indicates a closer match to the corresponding fault condition.

SF2 represents operating conditions as **binary semantic fingerprints**. Real-time comparisons use fast binary operations instead of computationally intensive matrix multiplications, enabling execution directly on standard industrial PCs.



WHAT SETS SF2 APART

SF2 - Explainable State Intelligence

- ✓ State-based analysis of multivariate raw sensor data
- ✓ No large labeled fault datasets required
- ✓ Direct Overlap as a measure of similarity
- ✓ Interpretable results – no black box
- ✓ Efficient overlap comparisons (low computational overhead)
- ✓ Fully local and air-gap ready

Training-Intensive Machine Learning

- ✗ Statistical decision models derived from training data
- ✗ Often require larger historical datasets
- ✗ Results depend on the model and training data
- ✗ Explainability depends on the model architecture
- ✗ Model complexity defines computational requirements
- ✗ Often relies on cloud services (data & security risk)

OPERATIONAL VALUE and Further Development

Earlier Maintenance
Assess emerging wear signatures before abrasion becomes critical

Precise Fault Location
Link detected events to specific conveyor sections

Scalable Coverage
Extend monitoring coverage by equipping additional containers

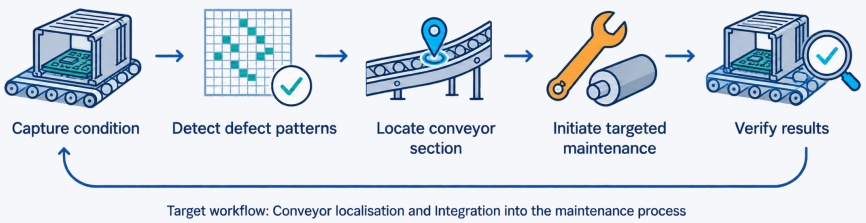
No Modification
The sensors travel inside the transport container

Lower Scrap Risk
Help protect high-value wafers from damage and particle contamination

Tests with the Infineon conveyor track date demonstrated the technical feasibility of detecting roller defects. For the pilot, SF2 plans to combine condition fingerprints with position tracking using AprilTags, a magnetometer and 60 GHz radar. This will help maintenance teams investigate recurring signatures, pinpoint affected roller sections and add newly confirmed patterns to the fault library.

PRECISION MAINTENANCE

From Defect Detection to Targeted Maintenance



Target workflow: Conveyor localisation and Integration into the maintenance process

CONCLUSION

The Infineon Thin[gk]athon demonstrated SF2's ability to recognise known roller defects from sensor data supplied by Infineon. SF2 works directly with time-series data, without requiring prior knowledge of the system architecture. Records of normal operation establish the baseline. Reference sequences from known defects then enable SF2 to recognise those signatures when they recur. Following the Thin[gk]athon, SF2 implemented the software on an Infineon board. Installed in a test carrier, the board provides a mobile platform for condition monitoring without additional sensors along the conveyor.

Learn more at www.SF2systems.com

SF2 SYSTEMS

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